CLOUDS AND THE EARTH'S RADIANT ENERGY SYSTEM (CERES)

CERES VALIDATION PLAN

MONTHLY REGIONAL, ZONAL, AND GLOBAL RADIATION FLUXES AND CLOUD PROPERTIES (SUBSYSTEM 8.0)

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CERES VALIDATION PLAN

8.0 MONTHLY REGIONAL, ZONAL, AND GLOBAL RADIATION FLUXES AND CLOUD PROPERTIES

8.1 INTRODUCTION

8.1.1 Measurement and science objectives

Regional, zonal, and global monthly mean values of shortwave (SW) and longwave (LW) radiative parameters at the top of the atmosphere (TOA) and surface and cloud property information in the atmosphere are important diagnostic tools for understanding and monitoring climate variation of the Earth-atmosphere climate system. For example, short-term global climatic fluctuations can be linked to interannual regional variations of outgoing longwave radiation (OLR) over the tropical Pacific Ocean. Zonal quantities are useful in studying global energy transport. Global averages can be compared with other historical data sets to detect climate temperature trends and evaluate large-scale climate anomalies. The science objective of the CERES monthly regional radiative fluxes and cloud data product (AVG) and CERES monthly zonal and global radiative fluxes and cloud data product (ZAVG) is to monitor these climatic quantities using estimates of SW and LW flux and cloud information from multiple EOS CERES instruments.

8.1.2 Missions

The CERES instruments will be flown on multiple satellites, which include TRMM, EOS AM-1, and EOS PM-1, to provide the diurnal sampling necessary to obtain accurate monthly averages of the TOA radiative parameters.

8.1.3 Science data products

The CERES regional, zonal, and global average data algorithm produces two science data products. They are monthly regional radiative fluxes and cloud data product (AVG) and monthly zonal and global radiative fluxes and cloud data product (ZAVG). The AVG data product contains a monthly and monthly-hourly average of the TOA and surface LW and SW radiative fluxes, together with LW and SW fluxes at standard pressure levels in between. It also contains observed cloud and clear-sky properties at the CERES 1-degree equal angle horizontal resolution. There will be a separate AVG data product for each spacecraft and for each combination of spacecraft. The ZAVG product is a summary of the zonal and global averages of the radiative fluxes and cloud properties. This is the CERES equivalent to the zonal averages and global averages in the Earth Radiation Budget Experiment (ERBE) S-4 data product. Similar to the AVG data product, there will be a separate ZAVG data product for each spacecraft and for each combination of

spacecraft. ZAVG contains monthly and monthly hourly averages for each of the 144 latitudinal zones and global averages. There are 116 and 114 data parameters in the AVG and the ZAVG science data products, respectively. These include mean estimates of SW and LW radiant flux at the TOA, at the surface, and within the atmosphere, mean estimates of cloud properties within the atmosphere, the standard deviations of these estimates, the maximum and minimum estimate, and scene information or cloud condition. A complete list of data parameters can be found in the CERES Data Products Catalog.

In the following sections, we outline the method adopted by the CERES Time Interpolation and Spatial Averaging (TISA) working group for validating the AVG and the ZAVG data product, the validation activities associated with both the pre-launch and the post-launch period, and the technique used for implementing the validation results in CERES data production. A final summary is given in Section 8.6.

8.2 VALIDATION CRITERION

8.2.1 Overall approach

The science algorithm for both the AVG and ZAVG data product is very similar to that of the ERBE-like algorithm. The averaging process is straightforward. The temporal interpolation necessary for calculating monthly means has already been performed in Subsystem 7, providing a complete data set with uniform time sampling. In addition, the fluxes are also calculated in Subsystem 7 at the levels at which they are averaged, so vertical interpolation is not required. Therefore, the monthly means of LW fluxes will be computed by simply averaging the month of synoptic data. For SW fluxes, the algorithm accounts changing solar conditions and the change of albedo as a function of solar zenith angle. Currently, all SW averages use the same techniques described in ERBE-like data processing (Subsystem 3.0) to correct mean fluxes to more accurately account for the contribution of the total integrated incident solar flux. Monthly means for the cloud category properties and the cloud overlap statistics are averaged linearly using data from the synoptic grids. Once regional means are computed for all parameters and all regions, these means are combined into zonal and global means using weighting factors to correct for the variation of grid box size with latitude. Additional details of this algorithm can be found in the ATBDs. The input data for this subsystem are the CERES SYN data product which contains synoptic radiative fluxes and cloud information computed at 3-hour intervals on a 1-degree equal angle ISCCP-type grid, and are based on measurements from multiple EOS and CERES instruments. These data are organized as files that each contain synoptic maps of the vertical structure of flux and cloud properties. A separate data file exists for maps at 0, 3, 6,., and 21 GMT for each day of the month. Sums of data values are maintained for each region. The outputs of this subsystem are monthly and monthly-hourly averages of radiative fluxes and cloud parameters at CERES 1-degree regional, zonal, and global resolutions.

The validation activities of this subsystem are an integral part of the CERES system. The purpose of this validation is to thoroughly test the subsystem and detect possible problems or errors.

The overall approach to validating the AVG and ZAVG data product follows that outlined for the ERBE-like data product. This includes validation of both the Subsystem 8.0 science algorithms and their associated science data products. Detail of this approach can be found in the validation plan of Subsystem 3 and will not be repeated here. In order to conserve resources, the CERES TISA working group will not validate every single data product listed in each of the AVG and ZAVG science products. Instead, the validation will only be performed for a set of emphasized parameters. Since Subsystem 8 data products contain the same parameters as those found in Subsystem 7, the validation data parameters for AVG and ZAVG data product will be exactly the same as those presented in the validation plan for SYN data product. These data parameters include:

(a) LW and SW TOA all-sky flux,
(b) LW and SW TOA clear-sky flux,
(c) all-sky window radiance,
(d) SW and LW surface flux,
(e) all-sky atmospheric flux,
(f) cloud amount,
(g) cloud particle size,
(h) cloud liquid and ice water path,
(i) cloud emittance and optical depth, and
(j) cloud height and thickness.

8.2.2 Sampling requirements

In order to validate AVG and ZAVG data products, we will require a minimum of one year of data from each of the CERES satellites. Additional data months are also required to perform data consistence test between different satellites (i.e., TRMM against AM, TRMM against PM, and AM against PM).

8.2.3 Measures of success

Reliable estimates of the uncertainties in the monthly mean data parameters due to time and space averaging processes for these parameters can be obtained from limited studies that are currently underway. These error estimates are given in Table 1 and 2 below. When applicable, estimates are given for both clear-sky and all-sky conditions. These table show the best estimates of the accuracy goal currently available for Subsystem 8. However, these accuracy values will be updated by TISA working group as more information becomes available.

In order to approach the validation activity in a systematic matter, the CERES science team has adopted a two-steps process for validating this subsystem. This process can be broken down into the pre-launch and the post-launch validation. The details of these validations are outlined in the next two sections.

8.3 PRE-LAUNCH ALGORITHM TEST/DEVELOPMENT ACTIVITIES

Pre-launch data set for validating this Subsystem is outlined in Subsystem 7 and will not be repeated here. Readers are referred to that subsystem for further details.

8.4 POST-LAUNCH ACTIVITIES

The post-launch validation of this subsystem is similar to those given in Subsystem 7 and will not be repeated.

8.5 IMPLEMENTATION OF VALIDATION RESULTS IN DATA PRODUCTION

The implementation of validation results is given in Subsystem 7 and will not be repeated. Readers are referred to that subsystem for further details.

8.6 SUMMARY

This document describes a plan of validating the CERES AVG and ZAVG data product. This plan is based on methods and procedures outlined in Subsystem 7. Reader are referred to that subsystem for further details.

Table 1: Accuracy Estimates for Monthly Mean Radiative Product.

Parameter	Clear-sky Bias Error	Clear-sky RMS Error	All-sky Bias Error	All-sky RMS Error
TOA SW_{up} (Watts/m^2)	2	2.5	0.4	2.5
TOA LW_{up} (Watts/m^2)	2	1.5	0.2	1.5
Surface SW_{up} (Watts/m^2)	1	5	1	5
Surface SW_{down} (Watts/m^2)	10	15	10	15
Surface LW_{up} (Watts/m^2)	2	10	2	10
Surface LW_{down} (Watts/m^2)	8	12	8	12
Atmospheric SW_{up} (Watts/m^2)	2	10	2	10
Atmospheric SW_{down} (Watts/m^2)	4	5	4	5
Atmospheric LW_{up} (Watts/m^2)	5	10	5	10
Atmospheric LW_{down} (Watts/m^2)	2	3	2	3

Table 2: Accuracy Estimates for Monthly Mean Cloud Product.

Parameter	RMS Error
Cloud amount	5%
Cloud particle size	40%
Cloud liquid/ice water path	100%
Cloud emittance	15%
Cloud visible optical depth	40%
Cloud height	10%

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DATA PRODUCTS/PARAMETER

- Monthly regional radiative fluxes and clouds data product (AVG) and monthly zonal and global radiative fluxes and cloud data product (ZAVG) contain monthly mean and monthly-hourly mean radiative flux and cloud property information on regional, zonal, and global scales.

MISSION

- TRMM, EOS AM-1, and EOS PM-1.

APPROACH

- Complete pre-launch science studies for improving and verifying TISA methods.
- Verify input/output operations and interface compatibility with other subsystems.
- Compare results with validation data set.

PRELAUNCH

- Complete validation of the science algorithm.
- Finish testing of the data processing system.
- Verify TOA results with historical ERBE TOA scanner data.
- Perform case study using CAGEX and TOGA data to verify science algorithm.

- Validate data processing using CERES end-to-end simulation.

POST-LAUNCH

- Primary comparison of TOA fluxes with geostationary data using narrowband-to-broadband conversion technique.
- Secondary direct verification of TOA fluxes (if available) with ERBE WFOV results, ScaRaB data, and GERB data.
- Comparison with cloud and radiation data collected from intensive field experiments (i.e., TOGA, FIRE, CAGEX, ARM/TWP, ARM/NSA, and UAV experiments).
- Comparison with cloud and radiation data collected for special validation region; including class 1 and class 2 sites (i.e., Walker Tower, Boulder Tower, NOAA sites, and BSRN sites)
- Additional intercomparison between TRMM, EOS AM-1, and EOS PM-1 data.

EOSDIS

- Special processing of CERES AVG and ZAVG data products containing validation sites.